OBSERVATIONS UPON THE BRAIN OF THE GORILLA.

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The brain of the Gorilla has been described by Gratiolet[1], Owen[2], Pansch[3], Thane[4], Bischoff[5] and Broca[6]. It should be mentioned, however, that the brains described by Gratiolet and Owen were in such a decomposed condition as to admit of but little more than a very general description, while the brain described by Pansch was the same that was afterwards described by Thane and Bischoff. Thane, moreover, does not appear to have ever seen the brain of the Gorilla he described, his remarks being based upon copies of the figures illustrating Pansch's paper. Bischoff, however, had the opportunity of studying the brain itself, the specimen previously described by Pansch having been submitted to him for examination, at his request, by Dr. Bolau. Finally, the brain described by Broca differed so much from that described by Bischoff that the latter wrote to Broca to say that he believed the brain described by the latter was not that of a Gorilla at all, but that of a Chimpanzee. It was undoubtedly, however, a Gorilla's brain. Since then Pansch has had the opportunity of dissecting three other Gorilla's brains the examination of which confirms his previous conclusions, based upon the brain of the Gorilla studied by Bischoff and himself.

It will be seen from the above resumé of the literature of the subject, that the opportunities of studying the brain of the Gorilla have been very few. In fact up to the present time, of the few Gorilla brains that have been obtained, supposing that described by Broca to have been a Gorilla, only five were in such a condition when received as to permit of description. It is to be hoped, therefore, that the following brief description of the brain of the Gorilla obtained in the neighborhood of the Gaboon river by the Rev. R. H. Nassau and presented by him to the Academy, through the courtesy of Dr. T. G. Morton, together with two others to be mentioned hereafter, will not be considered as superfluous, especially as it differs in several respects from the brains previously described.

[1] Comptes Rendus, 1860.
[2] Fullerian lecture, reported in Athenæum, March 23rd, 1861.
[3] Abhandlungen aus dem Gebiete der Naturwissenschaften, Hamburg, 1876, Jahresbericht über die Fortschritte der Anat. und Phys., 1879.
[4] Nature, Dec. 14th, 1876.
[5] Sitzungsberichte Acad. der Wissenschaften zu München, Band vii, 1877.
[6] Revue Anthropologique, 1878.

The brain, that of a young Gorilla, weighed one hundred and fifty grammes and measured ninety millimetres in length, seventy-five millimetres in breadth and sixty millimetres in height and was somewhat smaller than either of the brains previously described by Pansch and Broca. Each hemisphere of the cerebrum of the Gorilla, like that of man, is incompletely divided by more or less well defined and deep fissures into the following five divisions or lobes, viz: the frontal, parietal, occipital, temporal, and central lobes. The fissure of Sylvius, Pl. XI, fig. 2 S, begins at the base of the hemisphere behind the origin of the olfactory nerves, and laterally from the optic chiasma. Passing thence outwardly it reaches the arched lateral surface of the hemisphere and divides into two branches. The posterior branch, Pl. XI, fig. 2 S′, the longest of the two passing obliquely upward and backward terminates in the supra-marginal convolution of the parietal lobe. The anterior vertical branch, Pl. XI, fig. 2 S″, the smallest of the two into which the Sylvian fissure divides, passing obliquely forward and then upward and slightly backward, terminates in that part of the third frontal convolution which is situated below the second frontal fissure and in front of the pre-central fissure. The anterior horizontal branch, the third into which the Sylvian fissure divides in the brain of Man, and usually undescribed even in special works upon the brain, while absent in this specimen appears to have been present in the brain of the Gorilla described by Broca. It should be mentioned in this connection, that this fissure, regarded by Broca as being the anterior horizontal branch of the fissure of Sylvius, was described by Pansch as the anterior vertical branch, and by Bischoff as the orbital branch, both Bischoff and Broca regarding the slight indentation above but not passing into the posterior branch of the Sylvian fissure, as the ascending vertical branch. Such an indentation is present, at least in the right hemisphere of the brain of the Gorilla under consideration, but we cannot attach to it the morphological significance attributed to it.

The difference in interpretation of this fissure may be due to the fact of the brains described by Bischoff and Broca differing from each other and from that now described. Within the angle formed by the anterior and posterior branches of the Sylvian fissure may be seen, on the right side at least, of the brain of our Gorilla, the fifth lobe or island of Reil, the operculum leaving it partly uncovered. On the left side of the brain, however, the operculum fits so closely into the angle just referred to, that the island of Reil is completely

concealed. The operculum in the brain of the Gorilla, as in that of Man, is formed partly by the lower ends of the two central convolutions where they pass into each other, and partly by portions of the third frontal convolution and lower parietal lobule. The fissure of Sylvius, with its posterior branch, separates the frontal and parietal lobes from the temporal lobe. The central fissure, or fissure of Rolando, Pl. XI, figs. 1, 2 R, invariably present in the human brain as well as in that of most monkeys, is well marked in the brain of the Gorilla. Beginning on the upper surface of the hemisphere, slightly posterior to the middle line, it passes obliquely forward and downward to terminate near the upper border of the posterior branch of the Sylvian fissure, and is larger in the left than in the right hemisphere. The central fissure divides quite naturally in the Gorilla the frontal from the parietal lobes upon the upper surface of the hemisphere. The central fissure in its whole length is bordered, as in Man, by two convolutions, the anterior and posterior central convolutions, Pl. XI, fig. 2 a, b. The former we regard as belonging to the frontal, the latter to the parietal lobes. It has already been mentioned that the lower ends of the two central convolutions, where they pass into each other around the end of the central fissure, enter into the formation of the operculum.

While this is the case in the left hemisphere, it is not strictly so in the right one, since the central fissure is not only shorter on the right side than on the left, but also on account of the precentral fissure on the right side being longer than on the left, it passes down in front of the central fissure and almost reaches the posterior branch of the Sylvian fissure. The anterior central convolution, Pl. XI, figs. 1, 2 a, may be considered as giving origin at different levels from above downward to the superior, middle and inferior frontal convolutions, Pl. XI, figs. 2 c, d, e. The superior or first frontal convolution, Pl. XI, fig. 2 c, is separated from the middle or second frontal convolution, Pl. XI, fig. 2 d, by the first frontal fissure, and the second frontal convolution, Pl. XI, fig. 2 d, from the inferior or third frontal convolution, Pl. XI, fig. 2 e, by the second frontal fissure. It is impossible to say whether the convolution, which, passing downward and forward and bending around reaches the orbital surface of the frontal lobe, should be regarded as the continuation of the first or second frontal convolution or not. That the inferior part of the frontal lobe of the brain of the Gorilla, Pl. XI, fig. 2 e, should be regarded as homologous with at least

part of the third or inferior frontal convolution of the brain of Man, is shown by the fact that the convolution in question not only surrounds the end of the anterior vertical branch of the Sylvian fissure, but its inferior lower part passes as an arched convolution under the operculum into the island of Reil. As a confirmation of this view it will be observed that the pre-central fissure, into which the second frontal fissure runs, Pl. XI, fig. 2 d, passes downward between the anterior vertical branch of the fissure of Sylvius and the central fissure. The frontal lobes of the Gorilla differ, however, from those of Man in their anterior portion terminating in a point. The inferior or third frontal convolution in the brain of the Gorilla differs, especially from the corresponding convolution in Man, in not only being relatively smaller but in its orbital surface being hollowed out to such an extent that the portion of the inferior frontal convolution which in man surrounds or is below the anterior branch of the fissure of Sylvius, is absent. Indeed this should be so if, as we have just supposed, the anterior horizontal branch of the fissure of Sylvius is absent. It is hardly to be expected, therefore, that in addition to the olfactory fissure both the orbital fissure and the solco cruciform of Rolando[1] should be present in the brain of the Gorilla, especially as the fissures on the orbital surface of the frontal lobe in the brain of Man are variable in form. Only one fissure, in addition to the olfactory, is present in the orbital surface of the frontal lobe of the Gorilla's brain, and that resembles in both hemispheres rather the cruciform than the orbital fissure of Man.

If the interpretation just offered of the convolutions of the frontal lobe of the brain of the Gorilla be correct, it follows that the frontal lobe of the brain of the monkeys below the Gibbon must consist essentially of only two convolutions, the superior and middle frontal, the inferior frontal convolution being in them but little developed, as in *Macacus*, or absent altogether as in *Cercopithecus*. If such be the case then the convolution in monkeys described by Gratiolet[2] as being the inferior or third frontal must be regarded as being the middle or second frontal convolution, the inferior frontal convolution being but little, if at all developed. The view just offered, advanced also by Bischoff,[3] as to the nature of the convolutions of the frontal lobe in the

[1] Memorie della R. Accad. delle Scienze di Torino, 1829, T. XXXV.
[2] Mémoire sur les plis cérébraux de l'Homme et des Primates.
[3] Beiträge zur Anatomie des Hylobates leuciscus, p. 78, München, 1870.

primates, if correct, has a physiological as well as a morphological significance when considered in connection with the localization by Broca and other observers of the centre of articulate language in the inferior or third frontal convolution. For if the centre of speech be localized in that convolution, in its absence, though the larynx and nerves involved be present, the nervous plexus being incomplete, speech becomes impossible. The parietal lobe anteriorly is separated from the frontal lobe by the central fissure, posteriorly from the occipital by the external and internal occipital fissures and laterally and inferiorly, at least in great part, from the temporal lobe by the posterior branch of the Sylvian fissure. The posterior central convolution, the most anterior portion of the parietal lobe, may be regarded as giving origin to the superior and inferior parietal lobules which, passing backward towards the occipital lobe, are separated by the parietal fissure, Pl. XI, fig. 2.

The parietal fissure begins above and a little beyond the middle of the posterior branch of the Sylvian fissure and passes upward and forward, then obliquely upward and backward, and having nearly reached the top of the hemisphere turns again and finally passes into the external occipital fissure. Of the three secondary fissures of the superior parietal lobule, the most noticeable is that upon the surface of the hemisphere, just posterior to the central fissure which resembles very much in its form the cruciform fissure of the orbital surface of the frontal lobe. Of the convolutions entering into the formation of the inferior parietal lobule we regard those surrounding the terminations of the Sylvian and superior temporal fissures as being the supramarginal and angular convolutions.

The mesial surface of the parietal lobe of our Gorilla was not as well preserved as the remaining parts of the brain, nevertheless that part of it lying between the ascending branch of the calloso-marginal and internal occipital fissures was identified as præcuneus. The occipital lobe, forming the posterior portion of the hemisphere, is separated from the parietal lobe mesially and internally by the internal occipital fissure, and externally and laterally by the external occipital fissure. There are, however, no distinct boundaries between the occipital lobe laterally and inferiorly and the parietal and temporal lobes, the occipital passing continuously into the latter lobes as the occipital and occipito-temporal convolutions. The internal and external occipital fissures in the brain of the Gorilla might be viewed when

taken together as corresponding to the parieto-occipital fissure in the brain of Man, supposing the latter to be broader and bridged over by the first occipital convolution. It appears to us, however, as more probable that the internal occipital fissure alone in the Gorilla should be regarded as homologous with the parieto-occipital fissure in Man, the external occipital fissure in the Gorilla corresponding to the fissure described in the brain of Man as the transverse occipital fissure. That the latter view is the correct one is still further shown by the fact already referred to of the parietal fissure passing into the transverse occipital fissure, which is often the case in Man. On the mesial, as well as upon the superior surface, the occipital is as distinctly separated from the parietal lobe by the parieto-occipital fissure in the brain of the Gorilla as in the brain of Man. It should be mentioned, however, that in the brain of the Gorilla the parieto-occipital does not reach the calcarine fissure, as is usually the case in the brain of Man, the two fissures being separated by a distinct convolution, the "deuxième plis de passage interne" of Gratiolet, the "untere immere Scheitelbogen windung" of Bischoff. That is, the part of the occipital lobe described in the brain of Man as the wedge-shaped convolution or cuneus is divided in the brain of the Gorilla into an upper and larger, and a lower and smaller portion. A similar disposition usually obtains in the brain of the anthropoids and the lower monkeys, though this convolution may be absent on one side at least, as was observed by the author[1] in the case of a Chimpanzee. On the other hand, it should be mentioned, as stated several years ago by the author[2] in a communication made to this Academy, that he had observed this convolution, that is, the "deuxième plis de passage interne" of Gratiolet, in the brain of Man, and he takes this opportunity of calling attention to its presence in the brain of the white man as well as in that of the negro.

The calcarine fissure in the brain of the Gorilla passed into the hippocampal fissure, the convolution of the hippocampus being thereby separated from the convolution of the corpus callosum. In this respect the brain of the Gorilla agrees with that of the remaining anthropoids and lower monkeys, in which the calcarine usually passes into the hippocampal fissure. In the brain of the Gorilla described by Broca, however, the calcarine did not reach the hippo-

[1] Proceedings A. N. S., Phila., 1879.

[2] Proceedings A. N. S., Phila., 1880.

campal fissure, the convolution of the hippocampus passing continuously into the convolution of the corpus callosum, a disposition sometimes observed in other anthropoids and monkeys, as in the Chimpanzee, Gibbon and Spider Monkey, and which, with few exceptions, obtains in Man. The first occipital convolution, already referred to as separating the parietal and occipital lobes, in winding around the transverse occipital and the parieto-occipital fissures, Pl. XII, fig. 3P, forms an arch convex inward, then convex outward, serving to connect the occipital with the parietal lobe, Pl. XII, fig. 3 p, and more especially with the supramarginal lobule of the latter. Hence the various names, annectant, bridging convolutions, premier plis de passage externe, obere immere Scheitelbogen windung, given to this convolution as well as that of first occipital convolution.

This bridging or arching convolution is well developed in both hemispheres of the brain of the Gorilla, that of the right hemisphere being slightly less superficial than that of the left. On neither side of the brain, Pl. XII, fig. 3, of the Gorilla can it be said, however, that there exists an operculum, so striking a feature in the brain of the Chimpanzee and of the lower monkeys. The second occipital convolution, lying behind the transverse occipital fissure and outside the first occipital convolution, passes into the parietal lobe and more particularly into the angular convolution of the latter. The third occipital convolution, better defined on the right side than on the left in the brain of our Gorilla, passes from the posterior extremity of the hemisphere into the second and third temporal convolutions, Pl. XI, fig. 2 u, v. Unfortunately the inferior surface of the occipital lobe of our specimen was too much altered to admit of exact description. Judging from what remains of it as compared with the corresponding part of the brains described by Bischoff and Broca, the lateral and median occipito-temporal convolutions must have been present and well defined. The temporal lobe, while distinctly separated from the frontal and parietal lobes by the Sylvian fissure, passes without defined boundaries, as just seen, into the occipital lobe and consists essentially of three convolutions. The superior temporal convolution, Pl. XI, fig. 2 t, lying between the fissure of Sylvius and the superior temporal fissure, passes obliquely upward and backward into the superior marginal convolution. The middle temporal convolution, lying between the superior temporal and

inferior temporal convolutions, passes partly into the angular convolution and partly into the occipital lobe. The inferior temporal convolution, Pl. XI, fig. 2V, lying below the inferior temporal fissure, passes into the occipital lobe. The fifth lobe, insula or island of Reil, lying between the frontal, parietal and temporal lobes, is but little developed in the brain of our Gorilla, much less so than in the brain of the Chimpanzee described by the author. The insula, while entirely covered by the operculum on the left hemisphere, is but partly so in the right. Unfortunately the hemispheres were so altered on the mesial surface in the hippocampal region as to render impossible the demonstration of the lateral ventricle with its hippocampus major and minor, etc. Inasmuch, however, as the parts in question were demonstrated by the author in the brains of the Orang and Chimpanzee, as had been done previously by others, doubtless they existed in the brain of our Gorilla. As to the remaining parts of the brain of the Gorilla the medulla and pons did not present any especially noticeable peculiarites. The cerebellum, Pl. XII, fig. 4, however, was not only absolutely but relatively smaller than that of Man or of the Chimpanzee or Orang, and was entirely covered by the cerebrum, the posterior or occipital lobes extending beyond the cerebellum to an extent of several millimetres, and this though the brain had been lying in alcohol for many months.

The cerebellum was entirely covered, as was also the case in the two other brains of the Gorilla already referred to as having been too much altered to admit of description. It was equally well covered in the brain of the adult Gorilla sent many years ago by the Rev. Mr. Nassau to Dr. Morton but which was unfortunately in such a condition in other respects as to render it unfit for description. It may be mentioned incidentally that the cerebellum of the Chimpanzee is larger than that of either the Gorilla or Orang, and it would appear that while it is entirely covered by the cerebrum in the adult or nearly adult animal, it is partly uncovered by the cerebrum in the young animal. At least of three Chimpanzees dissected by the author, in the two young animals it was demonstrated before the brain was taken out of the skull that the cerebellum was not covered by the cerebrum, and the same condition was observed in the brain of the young Chimpanzee dissected by Mr. Arthur E. Brown, Superintendent of the Philadelphia Zoological

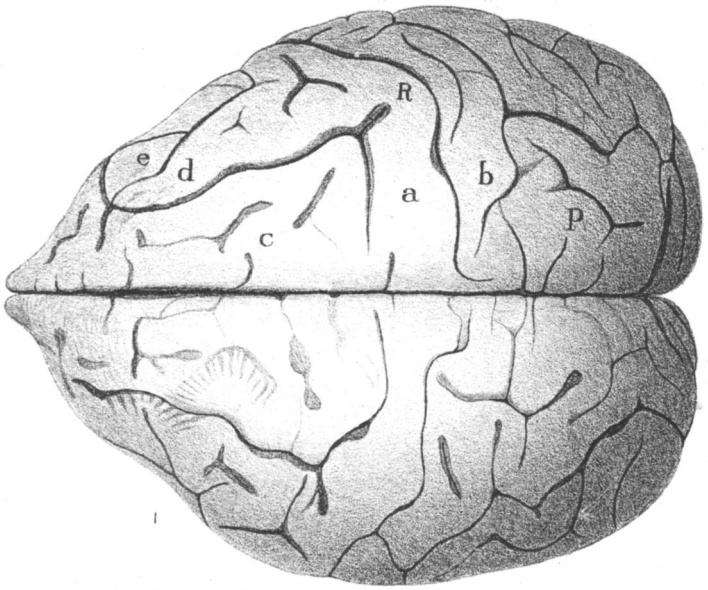
Garden, as well as in those described by Bischoff,[1] Muller,[2] Giacomini.[3] In the third Chimpanzee, a nearly adult animal dissected by the author, the cerebellum was entirely covered by the cerebrum, and such was stated to be the case in the brain of the Chimpanzee described many years ago by Marshall.[4] Of eight Chimpanzee brains, in six the cerebellum was found uncovered by the cerebrum, in two covered.

In a previous communication addressed to the Academy[5] it was stated that no one anthropoid ape was more closely related to Man in the totality of its organization than another and that no anthropoid now known could be regarded as the ancestor of the other anthropoids, still less as the ancestor of Man, each anthropoid agreeing in some respects with related forms and with Man and differing from them in others. A comparison of the brain of the Gorilla with that of the Orang, Chimpanzee and Man confirms the conclusion then arrived at. While the fissures and convolutions are disposed as we have seen in the brain of the Gorilla in the same manner, generally speaking, as in that of Man or of the Chimpanzee or Orang, it is nevertheless a low type of brain, being much less convoluted than the brain of Man or of either of the two other anthropoids. It might be supposed that this was due to the fact of the brain just described being that of a young animal. That such, however, is not the case is shown by the two other brains of the Gorilla not being any more convoluted, though both of them were larger and heavier and from older animals.

The brain of the Gorilla further differs from that of Man or of the Chimpanzee or Orang in the markedly pointed shape of its frontal lobe, in the absence of the lower portion of the inferior or third frontal convolution, and in its orbital surface being so concave. With reference to this portion of the frontal lobe in the Gorilla it may be incidentally mentioned that the corresponding part in the brain of the Chimpanzee and especially in that of the Orang, presents the cruciform and orbital fissures disposed exactly as in Man, the orbital fissure being readily distinguished from the anterior branches of the Sylvian fissure. Had all these fissures been present in the brain of their Gorilla the interpretation of the orbital fissure

[1] Gehirn des Champanzee, 1871.
[2] Archiv fur Anthropologie, 1887.
[3] Atti della R. Accad. Torino, 1889.
[4] Natural History Review, 1861.
[5] Proc. Acad. Nat. Sciences Philad., 1880.

would not have given rise to the discussion between Pansch and Bischoff already referred to. On the other hand the Gorilla agrees with the Orang in the superficial disposition of the occipital convolutions, the operculum, so conspicuous a feature in the brain of the Chimpanzee, being absent. If it be permitted in the absence of living links or sufficient fossil remains to speculate upon the development of Man and the anthropoids from lower forms of simian life it might be inferred from the character of the brain that the Gorilla had descended from some extinct *Cynocephalus*; the Chimpanzee and Orang from extinct Macacque and Gibbon-like forms, and Man from some generalized simian form combining in itself the characteristics of existing anthropoids. The remote ancestors of such extinct forms, to recede still farther in geologic time, such as *Necrolemur* of Filhol, *Notharctus* of Leidy, *Limnotherium* of Marsh, *Anaptomorphus* of Cope, the latter the most simian Lemur yet discovered, resembled, as their names imply, the living Lemurs of the present day, intermediate forms connecting the extinct and existing genera having once lived but having now passed away. Notwithstanding the value and importance of the remains of Mesodonts, Prosimiæ and Lemurs discovered, especially by Leidy, Marsh and Cope, in the eocene formations of the Rocky Mountains, a much more complete series of simian remains than is now available must be placed at the disposal of the evolutionist before even a general outline of the geneology of Man and the remaining primates can be established.



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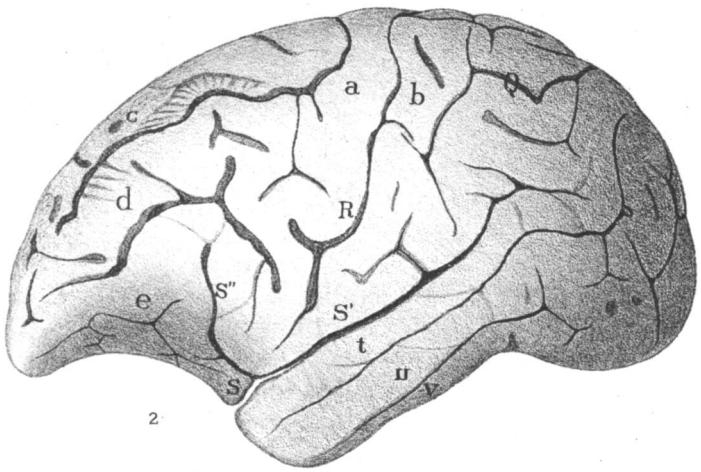

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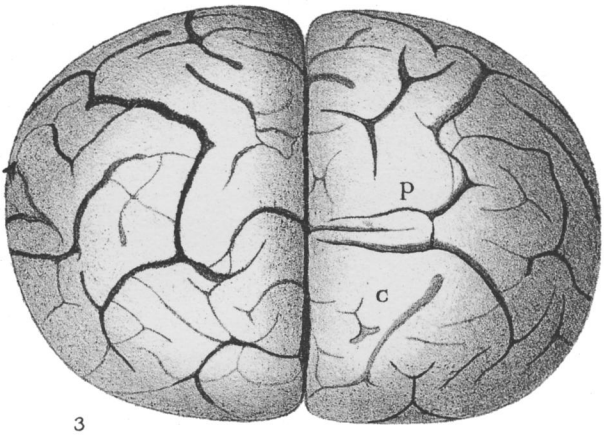
CHAPMAN, BRAIN OF GORILLA.



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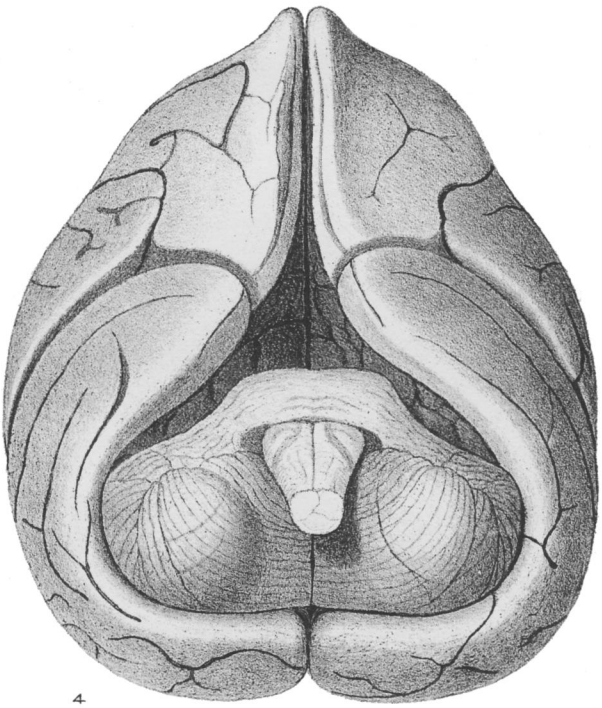

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